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THE WORK OF THE BELLE FOURCHE RECLAMATION PROJECT EXPERIMENT FARM IN 1916.

By Beyer Aune, *Farm Superintendent.*

INTRODUCTION.

The Belle Fourche Experiment Farm consists of 360 acres of land on the Belle Fourche Reclamation Project, near Newell, S. Dak., set aside by the Department of the Interior for experimental use. The experimental work relates chiefly to crops of local importance and includes experiments in crop rotation and tillage, tests of grain and forage crops, tests of trees both for windbreaks and for ornamental plantings, and tests of garden vegetables and small fruit. The arrangement of the fields and location of the experiments in 1916 are shown in figure 1.

COOPERATION.

The farm is in charge of the Office of Western Irrigation Agriculture of the United States Department of Agriculture, with the following offices cooperating:

Dry-Land Agriculture.—The Office of Dry-Land Agriculture uses about 20 acres of land above the irrigation canal for rotation and tillage experiments. These experiments include continuous cropping by ordinary methods and by moisture-conservation methods compared with alternate cropping and summer fallowing and a comparison of various crop rotations for the conservation of humus.

Cereal Investigations.—The Office of Cereal Investigations has charge of the variety testing and plant breeding of small grains.

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Alkali and Drought Resistant Plant Investigations.—This office does the variety-testing and plant-breeding work with forage crops and conducts studies of the water requirements of the different varieties and strains tested.

The above-mentioned offices have assistants detailed to the farm to supervise the work.

Biophysical Laboratory.—The Biophysical Laboratory cooperates in all climatological and physical observations. This work includes the

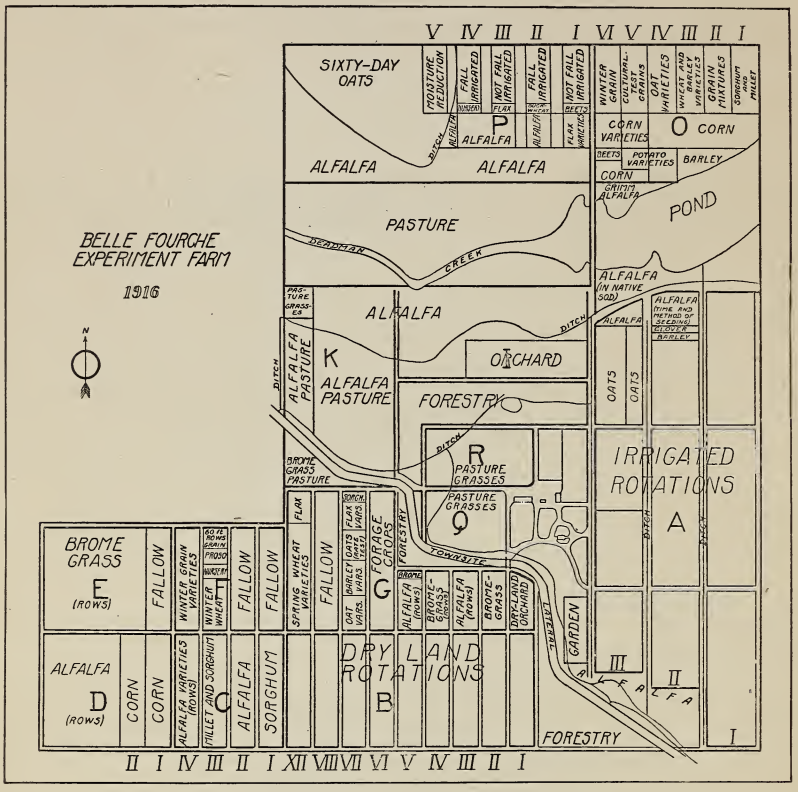

FIG. 1.—Diagram showing the arrangement of the fields and the location of the experiments at the Belle Fourche Experiment Farm in 1916.

measurement of rainfall, evaporation, wind velocity, temperature, and soil moisture.

Corn Investigations.—The Office of Corn Investigations cooperates in the variety testing of corn. About 1 acre is used for this work.

Forest Service.—The United States Forest Service cooperates in the testing of trees for wood-lot and windbreak purposes. About 9 acres of land are used for this purpose.

CONDITIONS ON THE PROJECT.

CLIMATIC CONDITIONS.

The precipitation in 1916 was 13.40 inches, which is 0.5 inch less than the normal rainfall for the last nine years. Most of this rain came during the growing season. The month of January was the coldest of any on record at the experiment farm. The spring opened early, and field work was commenced the first part of March. The season was ideal for this work, and while the ground had a fair amount of moisture all crops were slow in coming up, owing to the cold weather; yet in all cases good stands were finally obtained. The growing season throughout was very unfavorable for small grains, especially for wheat, which was badly damaged by rust. A severe windstorm occurred on May 9 and 10, damaging the small grain by moving the soil and leaving the crowns of the plants exposed. This was especially true on ground where a cultivated crop had been grown the previous year. The storm also damaged the Orman Dam to some extent by displacing some of the blocks on the face of the dam. One hailstorm occurred, on July 18, but the damage was limited to the north end of the project. The last spring frost occurred on May 16 and the first fall frost on September 14, leaving a frost-free period of 121 days, which is shorter by 12 days than the average for nine years.

Table I presents a summary of the climatological observations made at the Belle Fourche Experiment Farm from 1908 to 1916, inclusive.

TABLE I.—*Summary of climatological observations at the Belle Fourche Experiment Farm, 1908 to 1916, inclusive.*

PRECIPITATION (INCHES).

Year, etc.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1908	0.20	0.19	1.65	1.16	3.95	1.47	1.26	0.62	0.52	2.03	0.20	0.91	14.16
1909	.17	.23	.19	.84	3.87	5.59	2.45	.55	1.07	.76	.73	1.28	17.73
1910	.73	.70	.93	1.57	1.26	1.51	1.42	1.03	2.92	.27	.11	.10	12.25
1911	.13	.05	.09	.17	.45	.50	.80	1.86	.92	.39	.98	.30	6.64
1912	.24	.10	.71	2.32	2.26	.29	3.20	2.80	3.49	.51	.04	.13	16.09
1913	.57	.24	.99	.25	1.98	3.10	.35	.26	2.38	1.86	.10	.45	12.53
1914	Trace.	1.00	.29	1.09	2.22	2.09	1.34	1.12	.35	1.77	0	.43	11.70
1915	.92	1.01	.16	2.58	2.32	4.74	5.74	.44	1.26	1.25	.43	.17	21.02
1916	.36	.23	.98	.64	3.17	2.19	2.01	2.02	.20	.99	.33	.28	13.40
Average	.37	.79	.66	1.18	2.39	4.77	2.06	1.19	1.46	1.09	.32	.45	13.95

EVAPORATION (INCHES).

1908				5.53	5.92	6.82	8.08	7.87	6.75				40.97
1909				3.65	6.42	5.86	7.70	8.25	5.00				36.88
1910				5.41	5.31	8.98	10.42	7.30	4.31				41.73
1911				4.65	8.30	10.24	10.71	6.68	6.11				46.69
1912				4.85	6.42	8.18	7.92	6.60	3.71				37.74
1913				4.71	4.30	7.05	8.24	8.14	4.71				37.15
1914				3.37	5.13	6.71	8.74	6.97	4.19				35.11
1915				4.45	2.97	4.61	5.35	5.11	3.95				26.44
1916				3.68	5.26	5.13	7.51	5.43	5.42				32.43
Average				4.70	5.56	7.06	8.29	6.93	4.91				37.24

TABLE I.—*Summary of climatological observations at the Belle Fourche Experiment Farm, 1908 to 1916, inclusive*—Continued.

WIND VELOCITY (MILES PER HOUR).

Year, etc.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Mean:													
1908					8.3	7.2	5.0	6.8	6.5				
1909				9.1	10.1	6.2	6.0	5.6	5.7	6.3	5.5		
1910			6.3	9.2	8.2	9.3	7.7	6.6	6.2	7.1	6.5	9.2	
1911	7.5	5.8	9.6	9.2	11.6	9.1	7.9	7.3	7.7		10.0	7.6	
1912	6.9	7.3	6.6	9.5	11.1	7.6	6.0	6.9	7.6				
1913				6.2	5.9	6.8	5.8	5.1	4.5				
1914				8.2	7.7	6.7	5.0	5.0	6.2				
1915					7.4	6.2	5.0	4.1	5.9				
1916				7.8	8.7	7.3	5.1	4.4	6.2				
Maximum:													
1908					19.6	12.1	12.9	9.0	13.8				
1909				26.8	21.7	12.9	11.6	11.8	9.8	13.8	15.0		
1910			18.9	23.8	22.0	19.4	17.6	17.6	12.1	18.3	16.7	28.0	
1911	18.8	11.4	19.6	18.6	19.4	20.7	19.4	15.2	15.9		21.7	15.0	
1912	17.5	16.7	18.8	24.9	25.3	17.5	10.0	12.4	26.3				
1913				16.5	12.4	18.9	14.4	9.0	13.8				
1914				15.6	23.0	15.1	9.9	13.1	14.5				
1915					15.4	13.0	10.8	9.4	15.6				
1916				20.5	22.7	13.5	8.7	8.1	14.0				
Minimum:													
1908					2.1	1.7	2.5	2.9					
1909				2.5	2.6	2.9	2.5	2.5	2.5	2.1	.9		
1910			1.7	3.1	1.6	3.1	3.0	2.9	2.2	2.5	2.5	1.8	
1911	1.2	.8	2.4	3.3	3.9	4.5	2.8	2.6	2.5		1.3	2.1	
1912	.8	2.1	1.8	3.0	2.9	2.8	3.0	2.1	1.5				
1913				1.3	1.2	2.4	1.7	1.9	.9				
1914				4.0	2.0	2.9	1.6	2.1	2.2				
1915					2.0	2.0	1.5	1.8	1.5				
1916				2.0	2.0	2.2	2.1	1.6	2.3				

MONTHLY TEMPERATURE (° F.).

Mean:												
1908				48	52	63	73	68	64	45	37	22
1909	12	23	32	38	52	66	70	75	61	46	21	10
1910	18	8	46	51	52	68	76	68	59	51	31	25
1911	20	22	39	42	58	73	71	65	59	43	25	20
1912	12	25	19	47	55	66	70	68	52	45	38	28
1913	13	17	23	48	53	66	70	74	59	42	37	23
1914	27	14	33	43	55	65	76	69	62	49	39	15
1915	16	19	21	52	51	58	64	66	56	50	34	25
1916	5	22	34	42	52	60	77	67	58	43	32	
Maximum:												
1908				89	79	90	100	101	105	82	75	49
1909	50	51	65	73	84	95	100	105	96	84	73	49
1910	45	46	87	89	81	108	109	101	97	91	67	52
1911	59	61	78	88	90	101	105	100	94	82	58	51
1912	44	49	70	78	84	101	94	95	94	85	70	57
1913	48	62	54	89	95	98	101	104	97	80	64	51
1914	61	60	70	78	85	98	104	102	101	88	71	48
1915	53	40	50	83	84	84	88	97	100	81	68	57
1916	53	57	76	71	92	89	103	96	98	81	71	
Minimum:												
1908				5	29	39	43	39	22	22		−12
1909	−24	−19	12	6	22	45	41	45	31	11	− 7	−23
1910	−19	−26	22	24	27	36	44	32	30	13	8	−13
1911	−22	− 7	8	7	23	43	41	32	35	− 1	− 8	−25
1912	−32	−12	−15	22	32	39	40	47	24	22	11	2
1913	−32	−14	−20	24	26	45	42	45	29	14	14	− 1
1914	− 1	−28	4	8	30	44	48	40	35	25	9	−21
1915	−26	−11	− 9	26	28	33	41	40	30	21	7	−13
1916	−37	−12	−17	17	25	35	49	42	28	18	−18	

KILLING FROSTS.

Year.	Last in spring.	First in fall.	Frost-free period (days).	Year.	Last in spring.	First in fall.	Frost-free period (days).
1908	May 21	Sept. 22	128	1914	May 12	Oct. 4	145
1909	May 18	Sept. 24	128	1915	May 21	Sept. 14	116
1910	May 21	Sept. 26	127	1916	May 16	...do...	121
1911	May 12	Oct. 4	146				
1912	May 4	Sept. 25	144	9-year average			133
1913	May 6	Sept. 24	141				

AGRICULTURAL CONDITIONS.

The area of land cropped on the Belle Fourche project in 1916 was larger by 4,043 acres than in 1915. The total irrigable area of 802 farms on the project in 1916 was 60,035 acres. The total area actually irrigated was 48,468 acres, and the total area from which crops were harvested was 46,909 acres. The proportion of the acreage devoted to each crop was practically the same as in 1915 except alfalfa and pasture. Alfalfa showed an increase of 1,793 acres and pasture 2,859 acres. The total value of the crops produced on the Belle Fourche project in 1916 was $557,342, an increase of $94,292 over the production of 1915. The average yield per acre of all crops in 1916 was lower than in 1915 except for corn and alfalfa seed, while the value per unit of all crops was higher except in the case of alfalfa seed. The alfalfa hay shows the largest increase in value of any crop raised. The average farm value per acre of all crops was estimated at $11.88 in 1916, as compared with $10.80 in 1915.

The acreage, yields, and farm values of the crops produced on the project in 1916 are shown in Table II, the figures being obtained from the United States Reclamation Service.

TABLE II.—*Acreage, yields, and farm values of the crops produced on the Belle Fourche Reclamation Project in 1916.*

Crop.	Area (acres).	Unit of yield.	Yield.			Farm value.		
			Total.	Per acre.		Per unit of yield.	Total.	Per acre.
				Average.	Maximum.			
Alfalfa hay	17,945	Ton...	36,765	2.0	4.5	$7.00	$257,355	$14.34
Alfalfa seed	4,177	Bushel	5,320	1.3	7.0	8.00	42,560	10.19
Barley	2,740	...do...	42,804	15.6	62.0	.70	29,963	10.94
Beans	23	...do...	191	8.3	19.0	3.00	573	24.90
Beets, sugar	161	Ton...	1,515	9.4	17.0	4.50	6,919	42.34
Clover hay	48	...do...	78	1.6	3.0	8.00	624	13.00
Corn	3,846	Bushel	75,588	19.6	60.0	.80	60,470	15.72
Corn fodder	326	Ton...	733	2.2	6.0	5.00	3,665	11.24
Flax	493	Bushel	2,276	4.6	8.0	2.00	4,552	9.23
Garden	116	.....	.....	.....	.....	.....	5,080	43.80
Hay, native	2,121	Ton...	1,749	.8	2.5	9.50	16,615	7.83
Millet seed	48	Bushel	305	6.4	21.0	1.00	305	6.35
Oats	4,119	...do...	91,767	22.1	74.0	.40	36,707	8.91
Onions	1	...do...	4	4.0	4.0	1.00	4	4.00
Pasture	6,132	.....	.....	.....	.....	.....	27,826	4.55
Potatoes	169	Bushel	14,002	83.0	240.0	1.00	14,002	82.85
Rye	72	...do...	1,392	19.4	20.0	1.00	1,392	19.33
Wheat	7,554	...do...	38,222	5.1	20.0	1.25	47,778	6.32
Miscellaneous	176	.....	.....	.....	.....	.....	1,030	5.85
Less duplicated areas	3,358	.....	.....	.....	.....	.....	.....	.....
Total	46,909	.....	.....	.....	.....	.....	557,342	.....
Average	.....	.....	.....	.....	.....	.....	.....	11.88

Table III shows the annual average production and farm values of the principal crops grown on the Belle Fourche project in the years

1913 to 1916, inclusive, based on data obtained from the United States Reclamation Service. Alfalfa, corn, barley, and pasture show the largest increase in acreage, while the acreage of wheat was reduced nearly one-half from the 1913 crop. There is very little change in the average value per acre for all crops. This is due largely to the fact that each year extensive areas of land have been cropped for the first time, and as much of this land is not well farmed the average return per acre for the project is reduced. In the last four years there has been marked progress in development, and this is especially true in the districts that have been longest under irrigation.

TABLE III.—*Acreage, production, and farm values of the principal crops grown on the Belle Fourche Reclamation Project, 1913 to 1916, inclusive.*

Item and year.	All crops.	Alfalfa hay.	Alfalfa seed.	Barley.	Corn.	Hay, native.	Oats.	Pasture.	Wheat.
Acreage:									
1913	32,568	7,388	1,576	744	1,859	2,533	5,343	285	13,096
1914	36,709	9,745	1,416	1,448	4,415	2,236	6,392	3,604	7,885
1915	42,866	16,152	284	1,613	4,470	2,782	4,440	3,273	7,747
1916	46,909	17,945	4,177	2,740	3,846	2,121	4,119	6,132	7,554
Production:		*Tons.*	*Bushels.*	*Bushels.*	*Bushels.*	*Tons.*	*Bushels.*		*Bushels.*
1913		15,854	2,157	18,801	35,615	2,232	161,765		195,205
1914		20,473	3,205	34,718	106,280	1,911	209,813		108,880
1915		34,842	65	47,365	64,098	2,507	165,260		133,248
1916		36,765	5,320	42,804	75,588	1,749	91,767		38,222
Average yield per acre:									
1913		2.1	1.4	24.3	19.1	0.9	30.3		14.9
1914		2.1	2.3	24.0	24.1	.9	32.8		13.8
1915		2.2	.2	29.3	14.3	.9	37.3		17.2
1916		2.0	1.3	15.6	19.6	.8	22.1		5.1
Farm value per unit of yield:									
1913		$4.50	$6.00	$0.60	$0.80	$10.00	$0.40		$0.60
1914		4.50	7.30	.70	.70	10.00	.40		.90
1915		4.50	10.00	.65	.50	10.00	.40		.80
1916		7.00	8.00	.70	.80	9.50	.40		1.25
Farm value per acre:									
1913	$10.91	9.65	8.21	14.59	15.32	8.81	12.11	$6.98	8.94
1914	12.56	9.46	16.51	16.77	16.85	8.55	13.12	3.25	12.41
1915	10.80	9.90	2.00	19.05	7.15	9.00	14.92	4.32	13.76
1916	11.88	14.34	10.19	10.94	15.72	7.83	8.91	4.55	6.32
Total farm values:									
1913	355,380	71,343	12,492	10,861	28,492	22,320	64,706	1,990	117,123
1914	461,188	92,129	23,397	24,303	74,396	19,110	83,925	12,078	97,992
1915	462,050	156,789	650	30,787	32,049	25,070	66,104	14,105	106,598
1916	557,342	257,355	42,560	29,963	60,470	16,615	36,707	27,826	47,778

Table IV shows the live stock on hand on January 1 and December 31, 1916, their value, and the increase in total value. These figures were obtained from the United States Reclamation Service. As in 1915, there was a marked increase in the number of beef cattle. On January 1 there were 5,524 head and on December 31, 8,178 head, an increase of 2,654, or 48 per cent. The number of dairy cattle on January 1 was 2,200 and on December 31, 2,870, an increase of 670 head, or 30 per cent. The number of sheep on January 1 was 26,210, and on December 31, 32,152, an increase of 22 per cent. There was a slight decrease in the number of hogs.

TABLE IV.—*Inventory of live stock on the Belle Fourche Reclamation Project in 1916.*

Item.	Inventory, Jan. 1.			Inventory, Dec. 31.			Increased total value.
	Number.	Value.	Total value.	Number.	Value.	Total value.	
Horses	3,135	$92.80	$290.875	3.511	$88.83	$312.160	$21.285
Mules	65	120.00	7,805	86	104.30	8,970	1,165
Cattle:							
Beef	5,524	47.60	262,480	8,178	42.58	348.214	85.734
Dairy	2,200	56.10	123,195	2,870	56.92	163.355	40.160
Sheep	26,210	4.48	117,296	32,152	5.65	181.659	64,363
Hogs	14,798	6.75	99.640	13,631	8.48	115.613	15,973
Fowls	26.315	.48	12,533	27.094	.47	12.648	115
Bees, hives	326	7.45	2,429	541	5.34	2.888	459
Total			916,253			1.145,507	229,254

The total number of live stock on hand at the close of each year and their relative value as ascertained by the United States Reclamation Service for the years 1913 to 1916, inclusive, are shown in Table V.

TABLE V.—*Inventory of live stock on hand on the Belle Fourche Reclamation Project at the close of each year and values, 1913 to 1916, inclusive.*

Live stock.	1913	1914	1915	1916
Number:				
Horses	2,490	2,848	3,135	3,514
Mules	89	59	65	86
Cattle—				
Beef	[a] 2,758	2,514	5,524	8,178
Dairy		1,578	2,200	2,870
Sheep	12,872	25,740	26,210	32,152
Hogs	4,636	11,988	14,798	13,631
Fowls	23,125	29,186	21,315	27,094
Bees, hives	139	129	326	541
Average value per head:				
Horses	$90.32	$87.50	$92.80	$88.83
Mules	83.65	112.10	120.00	104.30
Cattle—				
Beef	[a] 46.14	46.50	47.60	42.58
Dairy		57.75	56.10	56.92
Sheep	3.76	3.76	4.48	5.65
Hogs	8.75	8.97	6.75	8.48
Fowls	.46	.49	.48	.47
Bees, per hive	5.76	6.20	7.45	5.34
Total value:				
Horses	$224,891	$249,150	$290,875	$312,160
Mules	7,445	6,635	7,805	8,970
Cattle—				
Beef	[a]127,214	116,901	262,480	348,214
Dairy		91,129	123,195	163,355
Sheep	48,471	96,782	117,296	181,659
Hogs	40,576	107,772	99,640	115,613
Fowls	10,586	14,252	12,533	12,648
Bees, per hive	801	801	2,429	2,888
Total	459,984	683,422	916,253	1,145,507

[a] Beef and dairy cattle for 1913 were not segregated.

The principal live-stock industries on the project show a steady increase each year, and this is especially true of cattle and sheep. In 1913 the total value of live stock on the project was $459,984, and on December 31, 1916, it was $1,145,507, an increase of $685,523 in four years.

The volume of the movement of live stock by railroad from and into the project is shown in Table VI. In 1915 the total number of carloads shipped into the project towns was 339. The total number shipped out was 1,059. In 1916 the receipts were 463 cars and the shipments 1,393 carloads.

TABLE VI.—*Carload shipments to and receipts of live stock at four shipping points on the Belle Fourche Reclamation Project in 1915 and 1916.*

Shipping point.	Forwarded.								Received.				
	Catt'e.		Sheep.		Hogs.		Horses.		Cattle.		Sheep.		Hogs.
	1915	1916	1915	1916	1915	1916	1915	1916	1915	1916	1915	1916	1916
Bellefourche	238	406	27	237	285	50	60	84	217	180	9	31	10
Fruitdale	17	28	34	10	7	19	.....	2	7	20	1	1	.....
Nisland	9	28	64	12	29	43	10	2	10	14	8	14	.....
Newell	50	162	74	118	141	81	14	11	43	85	28	118	3
Total	314	724	199	377	462	193	84	99	280	299	46	164	13
Increase or decrease in 1916	.....	410	.....	178	.....	−269	.....	15	.....	19	.....	90	13

The cattle, sheep, and hogs shipped into the project towns show a good increase during the year. The carload shipments of hogs are local shipments, as none have been shipped in from outlying districts. The pasturing of hogs and sheep with alfalfa and corn is coming into favor on the project and has given very satisfactory results, both as to returns per acre and in the saving of labor.

Because of the increased number of live stock, all farm crops have a ready market. This is especially true of alfalfa, hay, oats, and corn. The agricultural tendency is toward feeding more of the crops grown on the farm and selling live-stock products.

EXPERIMENTS WITH PASTURE GRASSES.

As agriculture develops on the Belle Fourche project, increasing interest is shown in live-stock industries. Among these the dairy industry is important, not only because of the direct returns it gives, but also on account of the indirect benefits that follow the use of manure on land to be used for cash crops. The economical feeding of dairy stock involves the use of grass pastures wherever possible. Preliminary experiments with pasture grasses were begun in 1913, and while these first experiments were unsatisfactory in some respects they served to show that even on high-priced irrigated land pastures might be profitably utilized. Irrigated pastures are of a permanent nature, and while the first cost of establishing them is somewhat high, the subsequent cost of care is not great. Good soil and frequent irrigation being necessary for maximum

results, pastures should be located on the best available ground, both as to fertility and as to ease of irrigation.

Carrying capacity.—During 1916 a pasturing experiment was conducted on some plats in field Q on which pasture grasses had been sown in the spring of 1915. There were four different mixtures involved in this experiment, as follows:

Mixture A.—Timothy, 4 pounds; Italian rye-grass, 2 pounds; orchard grass, 6 pounds; brome-grass, 2 pounds; redtop, 4 pounds; Kentucky bluegrass, 4 pounds; perennial rye-grass, 2 pounds; meadow fescue, 2 pounds; tall fescue, 2 pounds; western wheat-grass, 2 pounds; and tall oat-grass, 2 pounds. Total, 32 pounds per acre.

Mixture B.—The same as mixture A except that 2 pounds per acre of white clover and 2 pounds per acre of alsike clover were added.

Mixture C.—The same as mixture B except that 2 pounds of alfalfa per acre was added.

Mixture D.—Brome-grass, 20 pounds; slender wheat-grass, 12 pounds; alfalfa, 3 pounds. Total, 35 pounds per acre.

Mixtures A, B, and C were sown on quarter-acre plats, while 1 acre was sown to mixture D. These plats were top-dressed lightly with well-rotted manure early in the spring of 1916. All plats were given frequent irrigation, the aim being to keep the surface soil well supplied with moisture.

Two cows and one yearling heifer, with respective weights of 1,175, 910, and 600 pounds, were turned to pasture on May 8. Mixture D (brome-grass, slender wheat-grass, and alfalfa) produced by far the best growth early in the spring and was ready for pasture on May 8, while mixtures A, B, and C produced no pasture until June 5. The cows were pastured on mixtures A, B, and C whenever there was feed enough to support them, and the remainder of the time they were pastured on mixture D. The heifer was pastured on plat D continuously.

Table VII shows the pounds of milk and butter fat, pounds of gain, and cash returns per acre for each mixture.

TABLE VII.—*Results secured with four pasture-grass mixtures at the Belle Fourche Experiment Farm in 1916.*

Mixture.	Gain.	Results per acre.			
		Milk.	Butter fat.	Pasture for 1 cow.	Cash return for season.
	Pounds.	*Pounds.*	*Pounds.*	*Days.*	
A		3,124	124.12	136	$42.78
B		2,512	94.44	112	34.37
C		3,656	144.56	160	49.99
D	200	2,598	105.15	189	50.17
Average		2,972	117.06	147	44.32

In computing the cash return per acre the skim milk was valued at 30 cents per hundred pounds and the butter fat at 27 cents per

pound, while the gain in the weight of the heifer was calculated at 7 cents per pound.

The white and the alsike clovers failed to make a stand in either mixture B or C, so the difference in the number of days pastured between A and B is probably due to the fact that plat A was irrigated and pastured more frequently than plat B, as the two mixtures were otherwise the same. Mixtures C and D, containing alfalfa, gave by far the best returns; but these mixtures are not to be recommended for cattle, as there is too much danger from bloat, although there was no trouble from this cause during the past season.

In pasturing grass mixtures frequent irrigation is necessary, as most grasses are shallow rooted and feed near the surface and are unable to make use of water much below the first foot. During a dry season these grasses should be irrigated every week in order to make the maximum growth. For this reason the pasture should be divided into two parts, so that the stock may be kept from one pasture while irrigating and also to allow the grasses to make a new growth before pasturing again. During a rainy period the stock should be taken off, as the trampling of the ground when wet seriously injures the pasture.

Frequency of clipping.—The grasses used in mixtures A, B, C, and D were sown separately on small plats, so they could be studied in detail to better advantage.[1] These plats were divided into three sections. Section I was cut every 10 days, Section II every 20 days, and Section III every 40 days, in order to determine with what frequency these grasses should be cut to obtain the maximum production. The season, as to growth, was divided into three periods: Spring, to June 7; midsummer, June 7 to August 14; and autumn, August 14 to September 25.

The three species which were distinctly superior in the quantity of forage produced in 1916 are brome-grass, slender wheat-grass, and alfalfa. In the midsummer measurements white clover, alsike clover, and alfalfa showed superior growth. During this period there was also a more rapid growth of tall fescue, meadow fescue, redtop, and Kentucky bluegrass. In the autumn period white clover and alfalfa gave distinctly the highest yield, while tall fescue, redtop, and Kentucky bluegrass gave the highest yields among the grasses. Timothy made a poor growth during the entire season. There was no appreciable difference in yields in the forage whether the clippings were made every 10 days or every 20 days, but where cut every 40 days the forage yield was fully one-half more. White clover seemed to stand frequent clipping much better than alsike clover and its growth was much better in summer and autumn. In the spring the alsike clover

[1] The detailed observations on these plats were made by Mr. A. C. Dillman.

was much more vigorous. Alfalfa produced slightly more forage in the spring period than brome-grass, two and a half times as much in midsummer, and three times as much in the autumn period.

Pasture mixtures.—In order to determine whether mixtures less elaborate than those known as A, B, and C would prove satisfactory, a new series of plats was sown in 1916. It has been determined already, from previous seeding, that Italian rye-grass should be eliminated, as it produces too rank a growth the first season, crowds out the other grasses in the mixture, and the later growth is less vigorous.

The seeding made in 1916 included the mixtures at the rates per acre shown in Table VIII.

TABLE VIII.—*Mixtures of grass seed for pasture, showing the rates of seeding per acre at the Belle Fourche Experiment Farm in 1916.*

Kinds of seed.	Seed per acre (pounds).			
	Mixture 1.	Mixture 2.	Mixture 3.	Mixture 4.
Kentucky bluegrass	3	5		
Brome-grass	4		6	6
Meadow fescue	6	10		
Orchard grass	5			
Tall oat-grass	6		10	6
White clover	2	2	2	
Sweet clover				6
Total	26	17	18	18

The mixtures were sown on April 27 with a disk drill. Previous to seeding the mixtures, a nurse crop of barley was seeded at the rate of 1½ bushels per acre. This nurse crop was clipped at intervals during the summer. The purpose of the nurse crop is to keep down weeds and to prevent the soil from washing while the grasses are becoming established.

To secure a good stand the land should be prepared in the best manner possible. For this reason the land should be plowed in the fall and in the spring double disked, harrowed, and leveled just previous to planting, and great care should be used not to cover the seed too deeply. The grasses seeded in 1916 were irrigated four times during the summer, and a fairly good stand was obtained from all mixtures.

PASTURING SHEEP ON ALFALFA.

There is generally a prejudice against pasturing alfalfa with sheep because of the danger from bloat. However, several farmers on the project have been using alfalfa for sheep pasture, some during the entire season and others for short periods in the fall. Some farmers report no losses, while others report a few. In order to determine the carrying capacity of alfalfa for sheep, the gain per acre, and the

probable losses from bloat, an acre of alfalfa was fenced in 1915 and the third crop pastured. Ten lambs with an average weight of 75 pounds were turned in on August 28 and pastured for 40 days. The pasture was divided into two parts and grazed alternately. During this time the lambs made a total gain of 155 pounds on 1 acre of third-cutting alfalfa, or an average of 0.39 pound a day each.

On May 29, 1916, 10 yearling sheep were turned on the same acre of alfalfa that was used the previous season and were pastured until September 26, a period of 120 days. The pasture was divided into two parts and given frequent irrigation so as to keep the alfalfa in good growing condition. The total weight of the sheep when turned on the pasture at the beginning of the experiment was 1,419.5 pounds, and at the close of the period the weight was 1,656, a total gain of 266.5 pounds. The sheep during the winter and previous to the pasturing period received a small grain ration and all the alfalfa hay they would consume, so they were fat and very nearly full grown at the time they were turned to pasture, and therefore could not be expected to make much gain. This year's results indicate that an acre of alfalfa will maintain in good shape 1,400 to 1,700 pounds of live weight in sheep per acre if the pasture is divided into two lots and given frequent irrigation. At no time during the pasturing period was there any trouble with bloat or any other ill effect from pasturing alfalfa, nor was the alfalfa injured by the pasturing.

ROTATION EXPERIMENTS WITH IRRIGATED FIELD CROPS.[1]

In 1912 a series of experiments with crop rotations under irrigation was started. This series included twelve 2-year rotations, three 3-year rotations, four 4-year rotations, and five 6-year rotations; also nine plats used for continuous cropping to each of the crops used in the rotations. In 1914 duplicates of these continuously cropped plats were added to the series. In 1915 another 6-year rotation, No. 69, which consists of two years of corn, one year of oats, and three years of alfalfa, was added. The entire crop of third-year alfalfa and the corn is harvested by hogs. In 1916 another 6-year rotation, No. 71, was started. This rotation includes corn, sugar beets, oats, and three years of alfalfa. The entire crop of third-year alfalfa is pastured with ewes and lambs. The third crop from the second-year stand of alfalfa, the corn crop, and the beet tops (after the beets have been pulled) are to be harvested by spring lambs. Each crop in the various rotations occupies one-fourth of an acre, and at the present time 109 of these plats are included in the rotations. Field A, the location of which is shown on the map of the experiment farm (fig. 1), is devoted to the irrigated rotation experiments.

[1] This work was conducted after July 15 by Mr. George T. Ratliffe, scientific assistant, who prepared this report.

Crop yields.—Table IX shows the number of plats devoted to each crop, the maximum, minimum, and average yields per acre for each, and a comparison of the average yields in the four previous years, 1912 to 1915, inclusive.

TABLE IX.—*Yields of crops grown in the irrigated rotation experiments at the Belle Fourche Experiment Farm, 1912 to 1916, inclusive.*

Number of plats.[1]	Crop.	Yield per acre, 1916.			Comparison of average yield per acre.			
		Maximum.	Minimum.	Average.	1912	1913	1914	1915
25	Alfalfa.....tons..	5.2	1.17	3.42	.....	2.6	3.0	3.17
17	Sugar beets.....do....	12.06	2.93	7.03	7.6	7.8	11.6	9.2
7	Corn.....bushels..	46.9	21.9	39.5	28.7	34.0	43.6	27.6
7	Spring wheat...do....	16.1	6.3	10.0	22.1	19.9	25.7	20.9
3	Winter wheat..do....	14.3	7.5	11.9	.....	11.3	22.9	27.1
21	Oats.....do....	82.8	24.6	54.7	51.9	39.0	78.8	92.1
2	Barley.....do....	36.3	12.5	24.4	28.0	14.8	31.7	51.2
4	Flax.....do....	8.43	3.71	7.07	13.6	13.4	14.8	15.1
14	Potatoes.....do....	188.0	118.7	153.8	45.5	112.5	105.9	116.8
2	Clover.....tons..	.8	.52	.66	.....	.....	.44	1.18
2	Clover seed..bushels..	3.17	1.0	2.08	.....	.....	.....	1.77

[1] The number of plats given is the number in each crop during the season of 1916.

All small grain gave comparatively low yields in 1916, due to unfavorable climatic conditions. Wheat was badly rusted, but oats and barley were not noticeably affected by the disease.

Potato yields were above the average. The maximum yield of 188 bushels per acre was produced in a 3-year rotation of potatoes, beets, and oats manured. The manure is applied each year to the oat stubble at the rate of 12 tons per acre and plowed under in the fall.

The yields of sugar beets were lower than those recorded for the previous year. In 1916 the beets were thinned to a distance of 12 inches in the row, whereas in previous years the approximate distance of thinning was 8 inches. The additional space allowed did not increase the average weight per beet, as was to be expected. The maximum yield of 12.06 tons per acre was secured from a 2-year rotation of potatoes and beets, with manure applied to the beet ground after harvest and plowed under in the fall. This rotation has given the maximum yield for the past three years. Figure 2 shows this beet plat at the time of the first irrigation, July 26.

The average yield of alfalfa hay shown in Table IX is the average of all alfalfa plats in the irrigated rotations. This table shows that in 1916 the average yield per acre was one-fourth of a ton more than that for 1915. The maximum yield of 5.2 tons per acre was from the second-year stand in a 4-year rotation. The average yield from plats of established alfalfa (two or more years old) was 4.09 tons per acre. In comparing the first-season yields from five plats of spring-seeded alfalfa and three plats of fall-seeded alfalfa it is

found that the latter gave an average of 2.81 tons per acre and the former yielded but 1.61 tons of hay per acre. The fall-seeded alfalfa was drilled in oat stubble as soon as the oat crop was removed and received no other cultural treatment. It is important that the soil be kept moist after the alfalfa is seeded, to insure good growth before the ground freezes. Spring-seeded alfalfa followed beets. After the beet crop was harvested the land was left rough through the winter. In the spring it was disked, harrowed, and leveled before being seeded. Besides the smaller yield obtained from the spring-seeded alfalfa it is evident that the cost of obtaining a stand is greater than in the case where seed is drilled in small-grain stubble in the fall. From actual counts made it has been found that prac-

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FIG. 2.—Sugar beets on plat A-I-29 in the irrigated rotations at the Belle Fourche Experiment Farm in 1916. This plat is in a 2-year rotation of potatoes and beets and has produced the highest yield of beets each year for three years.

tically no winterkilling occurs when alfalfa is seeded in the stubble not later than the latter part of August.

The yields of oats, beets, and potatoes, arranged in their order from highest to lowest, together with a statement of the four preceding crops grown on each plat, are shown in Table X. As not all the rotations have completed their cycles of crop sequence, it is not considered safe to draw definite conclusions as to their comparative values. It must also be kept in mind in comparing these figures that the original fertility of the plats included in these experiments was probably not uniform.

Flax yields in 1916 were very low, the maximum being but slightly more than half the average yield for the previous season. No wilt was noticed in any of the plats and the only apparent reason for such low yields was the unfavorable climatic conditions.

TABLE X.—*Yields per acre of oats, beets, and potatoes, with statement of the preceding crops in the irrigated rotations at the Belle Fourche Experiment Farm in 1916.*

[Beets-manured indicates manure applied after beets; oats-manured indicates manure applied after oats; and oats-rye indicates rye seeded after oats in the fall to be plowed under as green manure the following spring.]

Oats.			Beets.			Potatoes.		
Preceding crops.	Rotation No.	Yield.	Preceding crops.	Rotation No.	Yield.	Preceding crops.	Rotation No.	Yield.
		Bushels.			*Tons.*			*Bushels.*
Alfalfa	61	82.8	Beets-manured	21	12.06	Beets	31	188.0
Do			Potatoes			Potatoes		
Do			Beets-manured			Oats-manured		
Potatoes			Potatoes			Beets		
Oats	44	80.3	Alfalfa	61	10.83	Potatoes	4a	175.0
Alfalfa			Do			Do		
Do			Potatoes			Do		
Potatoes			Oats-manured			Potatoes	21	169.7
Alfalfa	65	74.3	Beets	20	9.72	Beets-manured		
Alfalfa-hogged			Potatoes			Potatoes		
Corn-hogged			Beets			Beets-manured		
Flax			Potatoes			Beets	30	166.0
Potatoes	31	71.5	Beets	23	9.60	Potatoes		
Oats-manured			Oats-manured			Oats		
Beets			Beets			Beets		
Potatoes			Oats-manured			Potatoes	25	162.0
Alfalfa	62	63.6	Beets	40	8.83	Oats-manured		
Do			Alfalfa			Potatoes		
Do			Do			Oats-manured		
Corn			Potatoes			Potatoes	4	159.7
Oats-rye	27	62.6	Oats-manured	31	8.22	Do		
Potatoes			Beets			Do		
Oats-rye			Potatoes			Do		
Potatoes			Oats-manured			Potatoes	20	157.0
Corn	32	62.5	Beets	22	8.06	Beets		
Oats			Oats			Potatoes		
Beets			Beets			Beets		
Corn			Oats			Potatoes	27	154.3
Oats	48	58.4	Alfalfa	60	7.20	Oats-rye		
Alfalfa			Do			Potatoes		
Do			Potatoes			Oats-rye		
Wheat			Oats			Potatoes	24	151.3
Oats	24	58.0	Beets	2a	6.80	Oats		
Potatoes			Do			Potatoes		
Oats			Do			Oats		
Potatoes			Beets	2	5.84	Potatoes	26	149.0
Fallow	69	57.4	Do			Corn		
Alfalfa			Do			Potatoes		
Do			Do			Corn		
Corn-hogged			Beets	18	5.82	Potatoes	44	149.0
Oats	22	57.4	Wheat			Oats		
Beets			Beets			Alfalfa		
Oats			Wheat			Do		
Beets	30	56.0	Alfalfa	62	4.85	Potatoes	40	129.2
Potatoes			Do			Beets		
Oats			Corn			Alfalfa		
Beets			Oats			Do		
Potatoes	25	54.6	Oats	30	4.68	Beets	61	123.7
Oats-manured			Potatoes			Alfalfa		
Potatoes			Beets			Do		
Oats-manured			Oats			Do		
Potatoes	60	49.8	Beets	42	4.24	Beets	60	118.7
Alfalfa			Alfalfa			Alfalfa		
Do			Do			Do		
Do			Oats			Do		
Potatoes			Oats					
Oats	16	49.3	Beets	32	3.96			
Corn			Corn					
Oats			Oats					
Corn			Barley	66	2.93			
Oats-manured	23	43.8	Corn					
Beets			Winter wheat					
Oats-manured			Clover					
Beets								
Alfalfa	71	42.0						
Do								
Do								

TABLE X.— *Yields per acre of oats, beets, and potatoes, with statement of the preceding crops in the irrigated rotations at the Belle Fourche Experiment Farm in 1916*—Con.

[Beets-manured indicates manure applied after beets; oats-manured indicates manure applied after oats; and oats-rye indicates rye seeded after oats in the fall to be plowed under as green manure the following spring.]

Oats.			Beets.			Potatoes.		
Preceding crops.	Rotation No.	Yield.	Preceding crops.	Rotation No.	Yield.	Preceding crops.	Rotation No.	Yield.
		Bushels.			*Tons.*			*Bushels.*
Oats Do Do	1a	41.6						
Oats Beets Alfalfa Do	42	28.7						
Oats Wheat Oats Wheat	28	27.1						
Oats Do Do Do	1	24.6						
Average of all plats		57.3			7.10			153.7

From observation of the results of the past five years the most important indications are as follows: Small grains do better when following a cultivated crop than when following either grain or alfalfa. The yields of potatoes and beets are very materially increased by the addition of barnyard manure to the rotation. Alfalfa seeded in the late summer, after small grain has been harvested, gives greater net returns the first season than alfalfa seeded in the spring, because of the decreased cost of preparing the seed bed and the higher yields obtained.

Pasturing alfalfa with hogs.—Two of the 6-year rotations include one plat each of alfalfa pastured with hogs. Rotation 65, started in 1912, includes the following crops: Corn, flax, and oats, each one year, and three years of alfalfa. The 3-year-old stand of alfalfa is pastured with hogs and the corn is hogged off. While on the pasture the hogs are fed a daily ration of 2 pounds of corn for each 100 pounds of live weight. The alfalfa is pastured in two periods. Fall pigs, averaging about 100 pounds each, are used from April until in July, and spring-farrowed pigs are used for the remainder of the season. As soon as the corn is mature, hogs are put on the plat to harvest the crop. Rotation 69, started in 1915, includes two years of corn, one year of oats, and three years of alfalfa. Third-year alfalfa and both corn plats are handled in the same manner as the same crops in rotation 65.

In Table XI will be found a statement of results from pasturing alfalfa on these two rotations, including the total number of days

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FIG. 3.—Spring pigs on alfalfa pasture, Belle Fourche Experiment Farm, 1916. In 1916 the gains made by pigs on alfalfa pasture, supplemented with a 2 per cent ration of corn, amounted to about 2,000 pounds per acre.

of pasture furnished, the average live weight carried per acre, the grain fed and gains in live weight per acre, and the net returns per acre. For the sake of comparison between the rotations and between the results obtained in different years, a standard price of $1.75 per hundredweight for corn fed and 7 cents per pound for gain in live weight has been used in computing the net return per acre of alfalfa.

TABLE XI.—*Results of pasturing alfalfa with hogs at the Belle Fourche Experiment Farm, 1913 to 1916, inclusive.*

Year.	Rotation No.	Time on pasture.	Average live weight per acre.	Grain fed per acre.	Gains made per acre.	Grain fed per pound of gain.	Net returns per acre of alfalfa.
		Days.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	
1913	65	94	1,808	[a] 4,292	1,068	4.01	$21.14
1914	65	121	1,815	[b] 5,104	1,830	2.79	41.44
1915	65	132	2,002	[b] 4,787	2,024	2.36	60.32
1915	69	132	2,060	[b] 4,976	2,108	2.36	62.97
1916	65	119	2,286	[b] 5,290	1,962	2.70	47.41
1916	69	119	2,238	[b] 5,128	2,006	2.56	53.24

[a] Equal parts of ground oats, wheat, and barley. [b] Corn, fed on the ear.

In pasturing alfalfa it is necessary to keep the hogs off the field while the soil is wet. After each irrigation also it is preferable to allow the alfalfa to make new growth before the hogs are turned in. For these reasons it is best to practice what is ordinarily known as

the two-pasture method; that is, to fence the field into two equal parts and confine the hogs to each lot in alternate periods. It is not advisable to allow the alfalfa to become too closely pastured at any time, for such fields are very slow to recover. Alfalfa used for pasture requires more frequent irrigation than when harvested for hay.

Figure 3 shows spring-farrowed pigs just turned on to a fresh growth of alfalfa in rotation 65.

Hogging corn.—On September 16, the hogs which had been on alfalfa pasture in rotations 65 and 69 were turned into the corn on these same rotations. Three hogs, averaging about 100 pounds each, were used on each quarter-acre plat. A careful estimate of the yield of corn was made in each case and indicated 59.1 bushels per acre for rotation 65 and 47.7 bushels for rotation 69.

Figuring the gains in live weight at 7 cents per pound, the hogs gave returns of $36.26 and $31.92 per acre and paid for the corn at the rate of 61 cents and 67 cents per bushel on the two rotations, respectively. The corn was of poor quality, as it was frosted on September 14 while in the dough stage and did not fully mature.

In Table XII are given the results obtained from hogging corn during the five years, 1912 to 1916, inclusive.

TABLE XII.—*Results of harvesting corn with hogs at the Belle Fourche Experiment Farm, 1912 to 1916, inclusive.*

Year.	Rotation No.	Number of days.	Live weight per acre when turned on corn.	Gains per acre.	Estimate of corn crop.		Returns per acre.
					Yield per acre.	Price paid per bushel.	
			Pounds.	*Pounds.*	*Bushels.*		
1912	65	26	680	340	28.7	$0.83	$23.80
1913	65	11	1,632	560	34.0	1.13	39.20
1914	65	20	1,708	582	34.8	1.17	40.72
1915	65	15	1,620	548	40.6	.95	38.86
	69	10	1,780	451	34.0	.93	31.59
1916	65	24	1,252	518	59.1	.61	36.26
	69	26	1,268	456	47.7	.67	31.92

Harvesting alfalfa and corn with sheep.—The possibility of using sheep to harvest crops grown under irrigation is a problem which has been taken up in the new rotation, known as No. 71, started in the spring of 1916. This rotation includes the following crops: Corn, beets, and oats, each one year, followed by three years of alfalfa. The third-year stand of alfalfa is pastured with ewes and their lambs throughout the season. The last cutting of alfalfa from the 2-year-old stand, the corn crop, and the beet tops after the beets are harvested are to be harvested by the spring lambs.

Six ewes with lambs were put on the third-year plat of alfalfa June 8, but it was found that the growth was insufficient to support

that number of sheep. Three ewes and lambs were removed after 11 days. The remaining six sheep, three ewes and three lambs, were kept on the plat until September 6, at which time the alfalfa was completely pastured off. The three spring lambs which had been on the 3-year-old stand of alfalfa, together with seven other spring lambs which had been on green alfalfa, were turned into the corn and second-year plat of alfalfa on September 6. These lambs averaged 65.2 pounds each. The corn was just beginning to ripen at this time and the alfalfa had attained a growth of about 16 inches. The average total weight of sheep carried on the third-year alfalfa pasture for 76 days during the season was 1,854 pounds per acre. The total gain in live weight was 61.5 pounds for the plat, or 246 pounds per acre. Valuing this gain at 7 cents per pound, the sheep gave a net return per acre of $17.22. These sheep were fed no supplementary feed during this period. The 10 lambs used to harvest the corn, beet tops, and third-year alfalfa weighed 652 pounds when placed on the plats. They made a gain of 153 pounds during the 62 days required to clean up the crops. No trouble was experienced either with bloating or in getting the lambs to feed on either corn or beet tops. The usual charge for alfalfa pasture is at the rate of $15 per acre per season. Figuring the ratio of third-crop alfalfa to total yield for the season on other plats in the rotation, it is found that the value of the alfalfa pasture used by these spring lambs was $4 per acre. The standard charge for beet tops is at the rate of 25 cents per ton yield of beets. At this rate a charge of $1.45 per acre is made against the gross returns received from the lambs. Valuing the gains in live weight made by the lambs on the three crops at 7 cents per pound, they gave gross returns of $10.71 for the quarter-acre plat, or $42.84 per acre. After deducting $4 for alfalfa pasture and $1.45 for beet tops, the net return was $37.39 per acre. The estimated yield of corn from this plat was at the rate of 52.9 bushels per acre. On the basis of these figures the lambs paid for the corn at the rate of 70.7 cents per bushel, which is 6.7 cents per bushel more than the average price paid by hogs. From the observations of only one season it appears that lambs are at least as profitable as hogs for harvesting corn.

FALL IRRIGATION FOR ANNUAL CROPS.

Experiments in fall irrigation with oats, beets, flax, potatoes, barley, corn, and wheat were commenced in the autumn of 1913 and continued in 1914, 1915, and 1916.[1] These seven spring-planted crops were grown on duplicate tenth-acre plats in field P. The land

[1] The details of this experiment and a discussion of the results have been published elsewhere. See Farrell, F. D., and Aune, Beyer. Effect of fall irrigation on crop yields at Belle Fourche, S. Dak. U. S. Dept. Agr. Bul. 546, 13 p., 1 fig. 1917.

was fall plowed and one-half of the plats were irrigated in November each year. The average yields secured in this experiment in 1914, 1915, and 1916 and the three-year average yields are shown in Table XIII.

TABLE XIII.—*Results of fall irrigation for annual crops, showing the yields per acre at the Belle Fourche Experiment Farm in 1914, 1915, and 1916.*

Crop.	1914			1915			1916			3-year average.		
	Average yield.		Difference due to fall irrigation.	Average yield.		Difference due to fall irrigation.	Average yield.		Difference due to fall irrigation.	Yield.		Difference due to fall irrigation.
	Fall irrigated.	Not fall irrigated.		Fall irrigated.	Not fall irrigated.		Fall irrigated.	Not fall irrigated.		Fall irrigated.	Not fall irrigated.	
Corn....bushels..	49.6	49.3	+ 0.03	28.67	31.54	− 2.87	47.9	50.9	− 3.0	42.22	43.91	−1.69
Beets.....tons..	8.1	8.3	− .2	4.35	5.83	− 1.48	12.72	13.47	− .8	8.38	9.21	− .83
Potatoes..bush..	149.1	165.8	−16.7	92.40	102.40	−10.0	260.85	248.45	+12.4	167.4	172.1	−4.7
Wheat.....do....	30.0	21.9	+ 8.1	21.70	23.60	− 1.9	14.6	14.8	− .2	22.1	20.1	+2.0
Oats.....do....	43.4	43.9	− .5	65.80	80.20	−14.40	76.4	72.2	− 2.9	61.9	67.8	−5.9
Barley.....do....	27.9	27.3	+ .6	35.30	38.40	− 3.10	38.7	42.7	− 4.0	34.0	36.2	−2.2
Flax.....do....	13.7	16.1	− 2.4	17.60	17.70	− .10	9.75	11.95	− 2.2	13.68	15.23	−1.55

As shown in Table XIII, the differences in yields secured on the fall-irrigated land and on the land which received no fall irrigation have been slight. The results of the three years of experiment failed to show that fall irrigation had any material effect on the crop yields. It is concluded that on the gumbo soils of the Belle Fourche project the practice of fall irrigation is not to be recommended.

SMALL-GRAIN VARIETAL TESTS.[1]

Winter wheat, rye, emmer, and spelt.—The yields of winter grains in 1916 were much lower than those of the previous year, on account of the unfavorable weather conditions and injury from rust. The wheat and rye were sown in triplicated fiftieth-acre plats on disked corn ground, the wheat at the rate of 4 pecks and the rye at 5 pecks per acre. Single plats of emmer and spelt were sown along with the wheat and rye for comparison. All the winter grains were irrigated twice.

The Turkey selection produced the highest yield of grain both years, with the Kharkof (C. I. No. 1583) yielding slightly less. Winter wheat has outyielded winter rye, as shown by the average yields for the past two years. The yields of emmer and spelt are calculated at 32 pounds per bushel, so that the returns in pounds per acre are less than those of either wheat or rye. Considering also

[1] These experiments are conducted in cooperation with the Office of Cereal Investigations of the Department of Agriculture under the supervision of Mr. J. H. Martin, who prepared this report.

the lower feeding values of emmer and spelt it is clear that these crops are not to be recommended for this region. The yields are shown in Table XIV.

TABLE XIV.—*Annual and average yields of winter wheat, rye, emmer, and spelt grown at the Belle Fourche Experiment Farm in 1915 and 1916.*

Crop, group, and variety.	C. I. No. [a]	Yield per acre (bushels).		
		1915	1916	Average.
WHEAT.				
Crimean:				
Kharkof	1583	66.3	11.3	38.8
Do	4207	61.3	.....	.....
Turkey	3055	.....	8.7	.....
Turkey selection	3055–159	66.6	11.5	39.0
Beloglina	1667	[b] 52.1	8.7	30.4
Ghirka Winter:				
Ghirka	1438	.....	8.8	.....
Ghirka selection	5298	57.5	.....	.....
Do	1437–394	51.9	.....	.....
Do	5297	59.1	5.2	32.1
RYE.				
Swedish (Minn. No. 2)	137	44.6	10.8	27.7
North Dakota No. 959	175	[b] 38.8	11.7	25.2
EMMER.				
Buffum Black Winter	3331	.....	[b] 13.2	.....
SPELT.				
Beardless Brown Winter	.....	.....	[b] 7.8	.....

[a] Cereal Investigations number. [b] One plat only.

Spring wheat.—The spring-wheat varieties in 1916 were seeded on fall-plowed corn ground in triplicated fiftieth-acre plats at the rate of 5 pecks per acre. The plats were all irrigated on July 8. Cool, dry spring weather, together with some injury from soil blowing, affected the wheat crop considerably. All varieties except the Kubanka were badly infected by rust, which is chiefly responsible for the low yields in 1916. The Defiance variety was the most seriously infected. The Kubanka, a durum variety, has been the highest yielding spring wheat every year except 1912 and has the highest average yield for the entire period. Of the common wheats, the Marquis appears to be the best variety. The Defiance, a soft white wheat, has given very low yields. The annual and average yields of the spring-wheat varieties, in bushels per acre, are given in Table XV.

TABLE XV.—*Annual and average yields of spring-wheat varieties grown at the Belle Fourche Experiment Farm, 1912 to 1916, inclusive.*

Group and variety.	C. I. No.	Yield per acre (bushels).						
		1912	1913	1914	1915	1916	Average.	
							1912–1916	1913–1916
DURUM.								
Kubanka	1440	20.8	18.6	22.8	22.0	20.6	20.9	21.0
COMMON.								
Fife:								
Power	3025	19.5	17.0	17.0	14.7	8.4	14.5	14.2
Saskatchewan	.....	.....	.....	14.9	12.1	.....	.....	.....
Marquis	3276	.....	18.3	18.3	18.0	9.4	.....	16.0
Ghirka	1517	16.4	.....	.....	.....	.....	.....	.....
Bluestem: Haynes	2874	22.0	14.2	15.4	11.5	7.3	14.0	12.1
Preston: Pringle Champlain	4782	.....	.....	19.0	12.2	6.5	.....	.....
Miscellaneous: Defiance	3703	.....	11.7	18.0	8.0	2.0	.....	9.9

Oats.—The oat varieties in 1916 were seeded on fallowed corn ground in triplicated fiftieth-acre plats at the rate of 10 pecks per acre. The oats were irrigated twice. The yields were rather low, owing to unfavorable spring weather, soil blowing, and the presence of wild oats. The highest yielding variety in 1916 and for the 5-year period, 1912 to 1916, is the White Russian, a very late side oat. The midseason varieties yield slightly less than the White Russian, whereas the yields of early oats are much lower under irrigation. The annual and average yields for the five years from 1912 to 1916, inclusive, are shown in Table XVI.

TABLE XVI.—*Annual and average yields of oat varieties grown at the Belle Fourche Experiment Farm, 1912 to 1916, inclusive.*

Group and variety.	C. I. No.	Yield per acre (bushels).						
		1912	1913	1914	1915	1916	Average.	
							1912–1916	1915–16
Early:								
Sixty Day	165	[1] 25.0	47.1	32.5	34.0	28.8	33.4	31.4
Kherson	459	[1] 30.4	.....	.....	.....	.....	.....	.....
Kherson selection (Iowa No. 103)	729	.....	.....	.....	.....	20.2	.....	.....
Richland (Iowa No. 105)	787	.....	.....	.....	.....	18.1	.....	.....
Midseason:								
Swedish Select	134	[1] 35.2	33.0	41.6	46.5	36.9	38.6	41.7
Canadian	444	31.2	39.3	42.4	44.7	25.9	36.5	34.9
Lincoln	781	.....	.....	.....	50.7	36.1	.....	43.4
Silvermine	782	.....	.....	.....	52.3	41.6	.....	46.9
Great Dane	.....	.....	.....	[1] 32.8	.....	.....	.....	.....
Pete Edwards [2]	778	.....	.....	[1] 50.7	51.8	37.4	.....	44.6
Abundance	780	.....	.....	.....	.....	35.3	.....	.....
New White Danish	.....	.....	.....	.....	.....	34.8	.....	.....
Late:								
Mammoth Cluster	779	.....	.....	[1] 43.7	.....	24.7	.....	.....
White Russian	551	[1] 41.4	33.7	48.6	52.8	42.1	43.7	47.4
White Tartarian	300	[1] 46.8	.....	.....	.....	.....	.....	.....

[1] One plat only.

[2] Obtained from a farmer named Edwards, living in the vicinity of the experiment farm; similar to Swedish Select.

Barley and spring emmer.—Seven varieties of barley were seeded on fall-plowed corn ground in 1916 in triplicated fiftieth-acre plats at the rate of 6 pecks per acre. Three plats of White Spring emmer were also sown for comparison with barley on an adjoining series at the rate of 8 pecks per acre. The barley was irrigated once and the emmer twice. The yields in 1916 were not high, owing to unfavorable spring weather, soil blowing, and stem rust. The 2-rowed varieties of barley have outyielded the 6-rowed varieties, probably because they are later in maturing and are thus able to utilize a longer growing period. The yields of the hull-less barleys in pounds of grain per acre have equaled those of the 6-rowed hulled varieties. The Chevalier appears to be the best variety of barley under irrigation. The average yield of this variety during the past three years is 29 bushels, or 1,393 pounds, per acre. During this same period emmer produced 1,360 pounds of grain per acre. As the feeding value of emmer is lower than that of barley, the growing of this crop is not recommended. The annual yields from 1912 to 1916, inclusive, with the average for the past three years, are shown in Table XVII.

TABLE XVII.—*Annual and average yields of barley varieties and spring emmer grown at the Belle Fourche Experiment Farm, 1912 to 1916, inclusive.*

Group and variety.	C. I. No.	Yield per acre (bushels).					
		1912	1913	1914	1915	1916	Average, 1914–1916.
Six-rowed hulled:							
Coast	690	.....	.....	.....	23.0	15.2	.....
Manchuria (Wis. No. 13)	905	.....	25.8	21.8	20.9	14.7	19.1
Manchuria (Minn. No. 6)	638	16.9	.....	.....	.....	.....	.....
Manchuria (Minn. No. 105)	354	.....	23.5	17.8	.....	.....	.....
Odessa	182	17.4	.....	.....	.....	.....	.....
Two-rowed hulled:							
Chevalier	1142	.....	.....	26.8	37.2	23.2	29.0
Chevalier II	530	13.0	.....	23.0	39.2	23.9	28.7
Hannchen	531	19.8	32.9	15.0	.....	25.1	.....
Six-rowed naked:							
Himalaya (Guy Mayle, awned)	620	.....	.....	26.6	23.4	17.5	22.5
Nepal (white hull-less, hooded)	595	9.1	.....	19.2	20.4	14.9	18.1
Emmer:							
White Spring[1]	1524	24.5	27.8	34.0	58.0	35.6	42.5

[1] Yields of emmer computed at 32 pounds per bushel.

Flax.—The flax varieties in 1916 were seeded on potato ground in triplicated fiftieth-acre plats at the rate of 30 pounds per acre. The plats were all irrigated on July 9. The stands of flax were somewhat thinned by soil blowing at the time the plants came up. Rust was rather serious, especially on the Smyrna variety. The highest yielding variety in 1916 was the Russian, C. I. No. 19. This variety also has the highest 5-year average yield. The Select Russian, C. I. No. 3, is about as productive. The short, branching Smyrna flax has given very poor returns. The annual and average yields for the five years from 1912 to 1916, inclusive, are shown in Table XVIII.

TABLE XVIII.—*Annual and average yields of flax varieties grown at the Belle Fourche Experiment Farm, 1912 to 1916, inclusive.*

Group and variety.	C. I. No.	Yield per acre (bushels).						
		1912	1913	1914	1915	1916	Average.	
							1912–1916	1914–1916
Seed flax:								
Select Russian (N. Dak. No. 608)	1	.....	.....	3.7	.....	.....	.....	.....
Select Russian (N. Dak. No. 1215)	3	.....	.....	11.8	14.5	10.7	.....	12.3
Russian (N. Dak. No. 155)	17	10.1	.....	.....	.....	.....	.....	.....
Do	19	12.5	5.3	10.0	[1] 14.1	12.7	10.9	12.2
Common	.....	11.3	.....	.....	.....	.....	.....	.....
North Dakota Resistant No. 52	8	11.9	4.8	5.8	[1] 13.6	10.7	9.3	10.0
Short fiber:								
North Dakota Resistant No. 114	13	.....	.....	11.1	[1] 12.4	6.5	.....	10.0
Primost (Minn. No. 25)	12	11.1	5.3	11.6	12.9	9.0	9.9	11.1
Smyrna:								
Smyrna	7	.....	4.4	1.5	.....	.....	.....	.....
Do	30	.....	.....	.....	6.0	4.1	.....	.....

[1] Damaged by hail.

VARIETAL TEST OF CORN.

In 1916 eleven varieties of corn were tested on irrigated land. The varieties were grown in triplicate plats two rows wide and 132 feet long. Table XIX shows the results, air-dry weights of grain being given.

TABLE XIX.—*Average yield of corn in varietal tests at the Belle Fourche Experiment Farm, 1913 to 1916, inclusive.*

Variety.	1913		1914		1915		1916		4-year average yield per acre.
	Date of maturity.	Yield per acre.	Date of maturity.	Yield per acre.	Date of maturity.	Yield per acre.	Date of maturity.	Yield per acre.	
		Bus.		*Bus.*		*Bus.*		*Bus.*	*Bus.*
Marten White Dent	Sept. 11	60.4	Sept. 22	45.4	.....	23.7	.....	38.8	42.0
Lyman White Cap	.....	.....	Sept. 15	.....	.....	.....	.....	.....	.....
United States Selection No. 133	Sept. 13	56.2	Sept. 28	39.0	.....	20.4	.....	33.9	37.3
Payne White Dent	Sept. 11	55.3	Sept. 25	37.4	.....	22.2	Sept. 14	43.8	.....
Disco Dent	Sept. 15	45.5	Sept. 28	35.9	.....	.....	.....	.....	.....
Brown County Yellow Dent	Sept. 6	51.2	Sept. 20	34.7	.....	.....	.....	.....	.....
Ardmore Yellow Dent	...do....	49.2	...do....	34.4	.....	.....	.....	.....	.....
Northwestern Dent	Sept. 4	56.2	Sept. 15	31.5	Sept. 23	34.1	Sept. 14	42.2	41.0
Navajo	.....	.....	.....	.....	.....	19.9	.....	.....	.....
Disco Ninety-Day	.....	.....	.....	.....	.....	22.7	.....	26.5	.....
Disco Pride	.....	.....	.....	.....	.....	23.3	.....	.....	.....
White Australian	.....	.....	.....	.....	.....	22.4	.....	35.3	.....
Disco Eighty-Five-Day	.....	.....	.....	.....	.....	23.5	Sept. 14	41.4	.....
Gehu Flint	.....	.....	.....	.....	Sept. 13	28.7	Sept. 7	46.6	.....
Northwestern Dent × King	.....	.....	.....	.....	.....	.....	.....	39.4	.....
Early Huron	.....	.....	.....	.....	.....	.....	.....	25.8	.....
Many-Colored Squaw	.....	.....	.....	.....	.....	.....	.....	46.2	.....

The only varieties that were fully matured in 1916 were the Gehu Flint and Northwestern Dent. Payne White Dent was very nearly all matured. In the 4-year average, Marten White Dent shows the highest yield, with Northwestern Dent second. In 1916 the Gehu Flint gave the highest yield of any variety and also matured the ear-

liest. From the results obtained to date, Northwestern Dent, Payne White Dent, and Gehu Flint have made the best showing and have matured each year.

VARIETAL TEST OF POTATOES.

In 1916 twenty-one varieties of potatoes were tested. The varieties were planted in triplicate rows 132 feet long on field O, on land that had been in alfalfa the previous year. The yields secured in 1914, 1915, and 1916 are shown in Table XX.

TABLE XX.— *Yields per acre of potatoes in varietal tests at the Belle Fourche Experiment Farm, 1914 to 1916, inclusive.*

Variety.	1914		1915		1916		Average yield.
	Yield.	Marketable.	Yield.	Marketable.	Yield.	Marketable.	
	Bushels.	*Per cent.*	*Bushels.*	*Per cent.*	*Bushels.*	*Per cent.*	*Bushels.*
Extra Early Ohio	.....	.....	79.6	78.4	111.4	48.0	95.5
White Ohio	.....	.....	73.8	84.4	103.6	62.0	93.7
Carman No. 3	.....	.....	146.5	84.7	58.6	24.0	102.5
Red River Acme	.....	.....	72.1	80.5	115.9	48.0	94.0
Irish Cobbler	.....	.....	78.8	76.9	102.5	54.0	77.8
Peerless	.....	.....	154.9	87.6	90.6	47.0	122.7
Early Ohio	65.2	92.0	62.3	77.4	98.0	41.0	75.1
Albino	100.5	83.6	72.4	81.0	98.7	45.0	90.5
Peachblow	124.5	76.0	90.8	75.1	62.5	10.0	92.6
Burbank	.....	.....	120.8	91.9	92.5	23.0	111.6
Russet	97.7	80.0	126.1	86.0	78.9	17.0	100.9
Professor Maerker Silver Skin 4452	149.2	89.0	162.9	93.6	87.2	44.0	133.1
Delaware Pinkeye 8114	104.2	78.0	46.5	72.5	77.5	27.0	76.0
Norcross Keeper 15094	105.0	58.0	112.9	70.1	50.3	2.0	59.4
Pearl	116.2	70.0	62.7	87.5	.....	.....	89.4
Triumph	76.5	81.4	63.9	78.7	74.7	43.0	71.7
Rural New Yorker	.....	.....	120.8	91.9	66.7	20.0	93.7
Olds Prolific	.....	.....	177.8	92.0	47.8	12.0	112.8
Sir Walter Raleigh	.....	.....	135.0	91.1	55.8	18.0	95.4
Green Mountain	.....	.....	131.0	90.3	87.5	47.0	109.2
Gene Glover	.....	.....	.....	.....	109.2	62.0	.....
Eureka	.....	.....	.....	.....	106.4	58.0	.....

In 1914 and 1915 the late varieties produced a decidedly better yield than early varieties and a higher percentage of marketable tubers. In 1916 the early varieties showed the highest yields and also a larger percentage of marketable tubers. In 1916 the potatoes were grown on ground that had been in alfalfa the previous year. In spite of persistent cultivation, the alfalfa volunteered so badly that it seriously interfered with the proper maturing of the potatoes.

VARIETAL TEST OF ROOT CROPS.

In 1916 four varieties of root crops were tested on field P, Series I, on land that had been in winter grain the previous season. Each variety was planted in four rows, each 132 feet long. The rows were 20 inches apart, and the plants were thinned to 10 to 20 inches in the row. The yields secured in 1916 are given in Table XXI.

TABLE XXI.—*Yields of root crops at the Belle Fourche Experiment Farm, 1916.*

Variety.	Yield per acre.
	Tons.
Half sugar stock beets	29.76
Golden Tankard stock beets	24.63
Mammoth Long Red stock beets	23.75
Stock carrot	10.45

The half sugar stock beets gave by far the best yield and are a little the best in feeding value.

TREE PLANTING.

Tests of various kinds of trees for shade, ornamental, and windbreak purposes have been carried on in cooperation with the Forest Service since 1909. During the first three years all the work was done on land above the canal. In 1912 plantings were begun on irrigated land.

Dry land.—In the spring of 1909 about 3 acres were planted to the following trees: Cottonwood, white and golden willow, black locust, honey locust, green ash, Siberian pea, Russian olive, Scotch pine, Black Hills spruce, and red cedar. The season of 1909 was very favorable, and all the trees made a good growth during the season. In the winter of 1909–10 the black locust killed back rather badly and the Scotch pine entirely. In the spring of 1910 Austrian pine and hackberry trees were added to the plantings. The Austrian pine was a total failure, and only about half a stand of the hackberry was secured. The season of 1910 was extremely dry, but all trees which started growth in the spring made a good growth for the season except the willows, which were badly injured by drought. During the winter of 1910–11 there was no winterkilling of any species. The summer of 1911 was the driest on record, the rainfall for the year being only 6.64 inches. The trees made but little growth during the summer, but none were killed by drought. They all passed successfully through the winter of 1911–12 and made a good growth during the summer of 1912. There was an abundance of rain during the latter part of the summer and early fall, so that the season's wood did not ripen properly to go into the winter. During the winter of 1912–13 the cottonwoods, black locusts, and white and golden willows were killed to the ground. This was due to drying out rather than to frost, as these trees grow successfully where irrigated. The black locust is not hardy enough for this locality. The only varieties that came through the winter without killing were the green ash, Siberian pea, honey locust, and red cedar.

Table XXII shows the species that have survived, the date planted, average height, and the season's growth in 1916.

TABLE XXII.—*Results with experimental tree plantings at the Belle Fourche Experiment Farm in 1916.*

Species.	Date planted.	Height, 1916.		Season's growth, 1916.
		Ft.	*In.*	*Inches.*
Siberian pea	1909	4	10	10
Russian olive	1909	8		15
White elm	1909	7	10	16
Hackberry	1910	7		16
Honey locust	1909	7	4	19
Green ash	1909	7		14
Red cedar	1909	4	5	10
Black Hills spruce	1909	2		4

While all these species are slow growing, the fact that they withstand the severe conditions of drought and cold on the western Plains makes them valuable for shade and windbreak purposes.

Irrigated land.—About 7 acres are used for testing trees under irrigation for windbreak purposes. Plantings were begun in 1912. The varieties of trees now grown under irrigation are cottonwood, green ash, white elm, Russian olive, Siberian pea, honey locust, box elder, white willow, golden willow, jack pine, bull pine, Black Hills spruce, and white cedar. All these species have come through the winter without winterkilling except the honey locust, which killed back somewhat in 1915–16. The evergreens have come through the winter without injury and have made much better growth since the other trees have become of sufficient size to give them protection.

Table XXIII shows the species, date of planting, total height, and season's growth in the irrigated-forestry experiment for 1916.

TABLE XXIII.—*Species, date of planting, and record of growth of trees in the irrigated-forestry experiment at the Belle Fourche Experiment Farm in 1916.*

Species.	Date planted.	Height, 1916.		Season's growth, 1816.
		Ft.	*In.*	*Inches.*
Golden willow	1914	9		39
Chinese willow	1912	6	8	16
Chinese elm	1912	15	8	30
Chinese poplar	1912	10	6	27
White willow	1912	13	4	26
Siberian pea	1913	5	6	12
Russian olive	1913	9		37
White elm	1912	8		16
Green ash	1912	7	10	14
Cottonwood	1914	8	2	24
Honey locust	1914	5	5	36
Box elder	1914	5		29
Bull pine	1914		9	4
Jack pine	1914	2	2	10
Black Hills spruce	1916		4½	4
White cedar	1916		9	4

Success in growing trees depends upon the selection of species adapted to the soil and climatic conditions, proper preparation of the soil, careful planting, and the cultivation, irrigation, and protection of the trees after planting. All the varieties that have survived to date seem to be well adapted to local conditions. The land should be well prepared before planting by thorough cultivation and deep plowing in the fall. After planting, the trees must be protected from stock and given thorough cultivation and irrigation.

For ornamental plantings the following can be recommended: Van Houtte's spirea, Physocarpus opulifolius, yellow currant, the Rugosa rose, Siberian dogwood, purple barberry, common elder, lilac, and snowball.

Approved:
WM. A. TAYLOR,
Chief of Bureau.

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